VALIDATION OF BUOY AND SATELLITE DATA FOR NEAR-REAL TIME ASSESSMENT OF CHANGES IN BIO-OPTICAL PROPERTIES IN COASTAL WATERS (ENGLISH CHANNEL)

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GOALS

To determine and model the nature, scale and relative importance of physical parameters that control surface bio-optical variability in coastal waters. A basis will be established for interpretation of ocean colour imagery using quantitative procedures.

OBJECTIVES

This project aims to aims to explain, analytically, the physical and bio-optical variability observed within a defined study site. The region of interest is shown in figure 1. Tidal velocities range from 25 to 75 cms^{-1}. The stratification parameter (S, see Pingree & Griffiths, 1978) ranges from $1.75 < S < 3$. The water column exhibits the classical shelf sea progression of Spring stratification and Autumn mixing, resulting in Spring and Autumn blooms with Summer sub surface chlorophyll maximum (Holligan & Harbour, 1977).
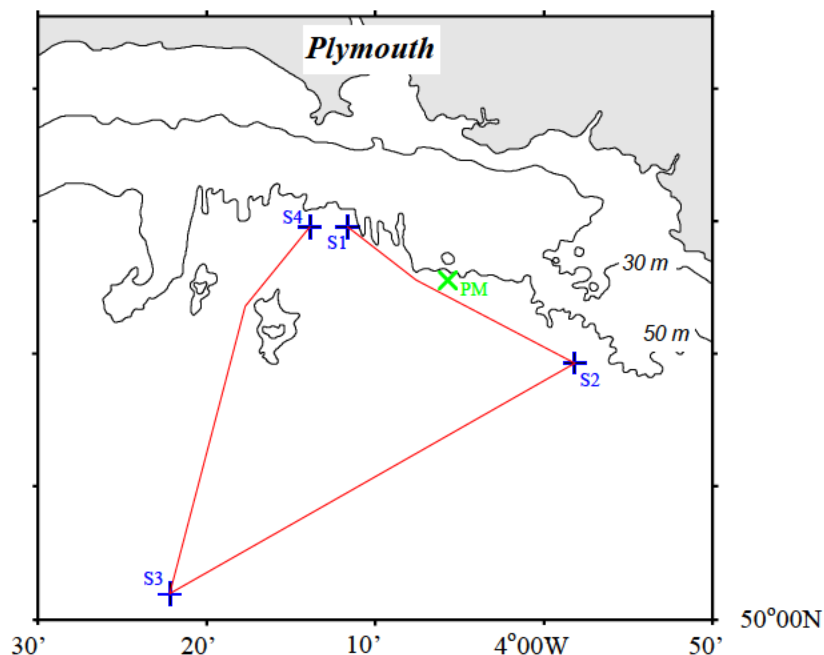

Figure 1 - *Chart of region of interest. Red line shows the repeated cruise track; S1 to 4 show the repeated sampling stations; PM shows the site of PlyMBODy (see text).*

Report Documentation Page

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APPROACH

The three main components of the project are as follows: To describe (through *insitu* and remotely sensed measurements) the physical and bio-optical state of the region of interest (see table 1); To use these data to parameterise an in-water optical model (based on Mobley 1994): To combine the optical model with a physical-biological model (based on Prestidge & Taylor, 1995), thereby relating optical variability to physical forcing.

Measurement type	Parameter	Sampling platform
Physical	Temperature	UOR, PlyMBODy, remote sensed sea surface temperature
	Salinity	UOR, PlyMBODy
Optical	$L_w(\lambda)$	UOR, PlyMBODy, remote sensed ocean colour
	$K_d(\lambda)$, $K_u(\lambda)$, $E_d(\lambda)$, $L_u(\lambda)$	UOR, PlyMBODy
Biological	HPLC pigments	underway, water bottle
	Invitro fluorescence	underway, water bottle
	Invivo fluorescence	UOR, PlyMBODy

Table 1 - Measurement techniques. $L_w(\lambda)$ is water leaving radiance at SeaWiFS wavelengths: $K_{u,d}(\lambda)$ are diffuse attenuation coefficient at SeaWiFS wavelengths: HPLC is high performance liquid chromatography (see Barlow & Mantoura, 1993, for methodology): UOR is the Undulating Oceanographic Recorder (see Robins et al (1996) for description): PlyMBODy is the Plymouth Marine Bio-Optical Data buoy (see Pinkerton & Aiken, 1997, for description).

WORK COMPLETED

Table 2 is a list of sampling trips undertaken during 1996 and 1997, which sampled part or all of the cruise track in figure 1. All data collected has been processed and calibrated. Example analysis of the data is presented in the results section.

Date	17.May.96	20.May.96	18.Jun.96	23.Jun.96	30.Jul.96	28.Aug.96	4.Sep.96	5.Sep.96
UOR	58	0	0	142	94	107	112	0
HPLC	0	6	12	12	10	12	11	15
WB cast	0	1	0	4	0	2	0	0
Date	6.Sep.96	.2.May.97	8.May.97	21.May.97	10.Jun.97	18.Jun.97	24.Jun.97	10.Jul.97
UOR	0	0	0	0	114	0	162	170
HPLC	10	18	9	13	20	1	30	29
WB cast	0	0	0	0	4	1	0	4
Date	11.Jul.97	29.Jul.97	19.Aug.97	2.Sep.97	11.Sep.97	17.Sep.97	23.Sep.97	
UOR	143	185	122	0	0	0	0	
HPLC	25	35	13	20	24	25	25	
WB cast	3	4	2	3	4	4	4	

Table 2 - *Summary of data gathered - Number of UOR profiles, number of surface HPLC samples, number of water bottle casts (WB cast).*

Successful *insitu* engineering and calibration tasks were carried out on PlyMBODy during April and May 1997. Time series of PlyMBODy data runs from June onwards. Additional Data in support of the sampling trips was collected in August and September.

MOS-IRS (ocean colour satellite) images are available in near-real time. The sampling trip on 19th August 1997 was in response to a clear MOS-IRS image received on 14th August 1997. All other clear sky images for 1997 have been processed.

Meteorological data for 1979 to 1996 from the Plymouth Meteorological Station have been obtained. Significant variables include hourly solar irradiance and wind velocities. Tidal data is currently available from a 5x5 km grid tidal model (Pingree & Griffiths), with verification against standard tidal charts.

RESULTS

The relationship between the optical data collected by the UOR and the surface chlorophyll data measured by the HPLC technique are presented in figure 2. This is a plot of chlorophyll-a concentration against the diffuse downwelling attenuation coefficient at 490 nm ($K_d(490)$), from all cruises conducted in 1997. Confidence in the lower limit of the data is demonstrated as follows; the intercept falls at $K_d = 0.03$ m^{-1}, which is that of pure water (Smith & Baker 1978a), furthermore, the slope (0.025 m^{-1}.(mg m^{-3})$^{-1}$) is similar to, but larger than, the theoretical minimum slope if chlorophyll-a was the only in-water constituent (i.e. the chlorophyll-a specific diffuse attenuation coefficient; 0.016 m^{-1}.(mg m^{-3})$^{-1}$, Smith & Baker 1978b). The lower limit has been used to identify case 1 water (i.e. phytoplankton and by-products are optically dominant, Morel, 1977), with distance away from this line indicating the increase in significance of non-phytoplankton constituents (case 2 water).
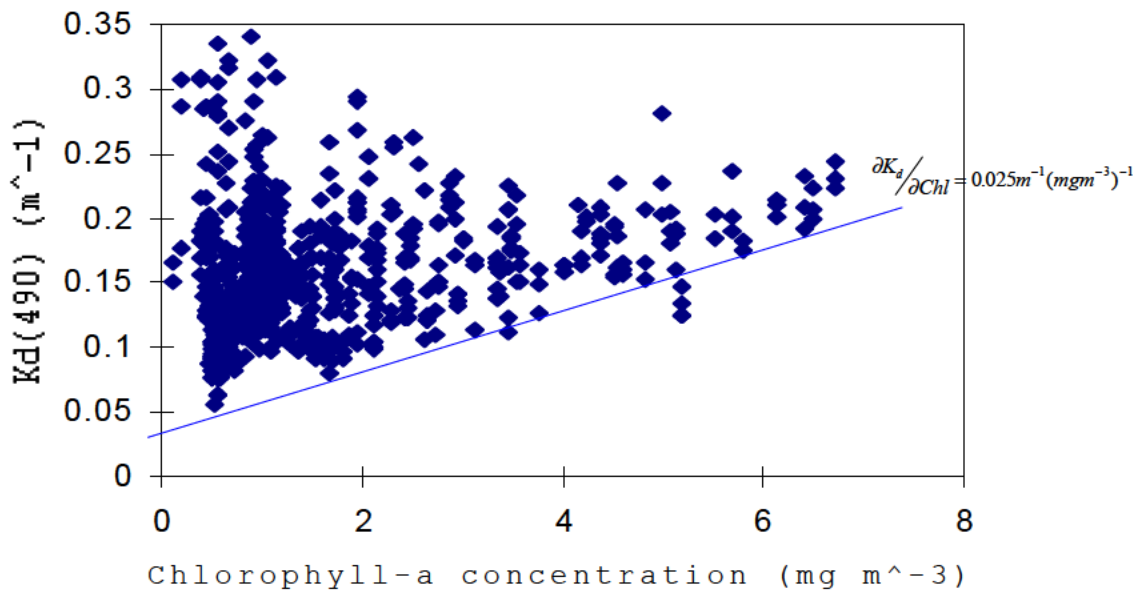

Figure 2 - Plot of diffuse downwelling attenuation coefficient against chlorophyll-a concentration. Case 2 and Case 1 are water types (see text).

The continuous UOR data are separated into vertical profiles, one for each undulation from 3 to 40 m depth, which are then used to calculate the values displayed in figure 3. Figure 3 is a summary of data collected on 11th September 1997. The track shown in figure 1 was followed.

Figure 3 and table 3 show the behaviour of several bio-optical variables in well mixed, frontal and stratified water masses. Each frontal region encountered was associated with increase in surface values of $K_d(490)$ and $a(670)$, which were due, wholly or in part, to an increase in phytoplankton (shown by chlorophyll values). The well mixed region displayed low values of $K_d(490)$ and $a(670)$,

due to low chlorophyll concentrations. The stratified region showed intermediate values, but the relatively high $K_d(490)$ indicated that the water was case 2 (referring to figure 2), which was unexpected in stratified water, and will be a focus of further investigation.
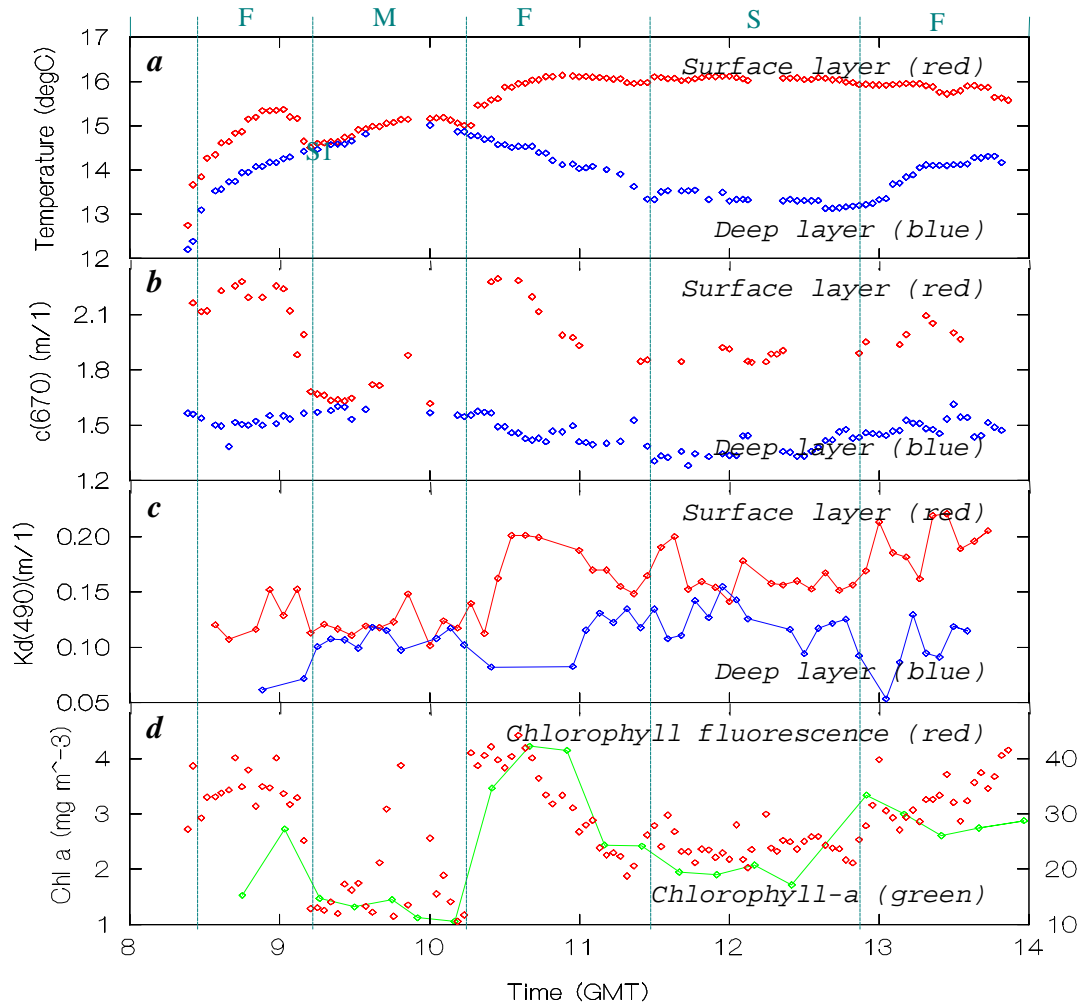

Figure 3 (a to d) - *Cruise data from 11 Sept '97.* ***A.*** *plots temperature against time (1 h equivalent to 16 km along track distance), for both the surface layer (above the thermocline) and deep layer (below the thermocline).* ***B.*** *is a time plot of beam attenuation at 670 nm, measured by a transmissometer.* ***C.*** *is a time plot of diffuse downwelling attenuation coefficient at 490 nm, measured by a cosine irradiance meter.* ***D.*** *is a time plot of chlorophyll fluorescence, measured by an invivo fluorometer, and chlorophyll-a concentration, measured by the HPLC technique. F, M and S refer to Frontal, Mixed and Stratified regimes listed in table 3.*

	Mixed	Frontal	Stratified
Δ Temperature (^{o}C)	0	0 to 2.7	>2.7
c(670) surface (m^{-1})	1.7	2 to 2.3	1.9
K_d(490) surface(m^{-1})	<0.15	0.12 to 0.22	0.15 to 0.20
Invivo Chlorophyll-a fluorescence	14	20 to 40	20 to 25
Chlorophyll-a (mg m^{-3})	<1.3	1.3 to 4	2

Table 3 - *Data summary from Figure 3: c(670) is the beam attenuation coefficient at 670 nm: K_d(490) surface is the diffuse attenuation coefficient between 9 and 19 meters depth: K_d(490) deep is the diffuse attenuation coefficient between 20 and 30 meters depth.*

IMPACT / APPLICATIONS

The physical-biological model estimates temperature, salinity and chlorophyll concentrations for the upper and lower mixed layers, separated by a gradient layer. The first runs of the model and preliminary data validation have been completed. Comparisons with *insitu* data are anticipated. The optical model is in development. The completed bio-optical model is designed to be optimised using remote sensed sea surface temperature and ocean colour data, thereby facilitating transferability to other regions.

TRANSITIONS
none

RELATED PROJECTS

The Natural Environmental Research Council's Remote Sensing and Data Analysis Service work with this project on the automated processing (to level 2) and archiving of LAC data (including AVHRR, MOS-IRS and SeaWiFS sensors) for the study site. CZCS data, from 1979 to 1984, have been processed and archived. Computer programs have been developed to allow spatially consistent data to be extracted from all image types, to facilitate direct comparisons with *insitu* data and model output .

REFERENCES

Barlow, R.G., Mantoura, R.F.C., Gough, M.A. & Fileman, T.W., 1993: Pigment signatures of the phytoplankton composition in the northeastern Atlantic during the 1990 spring bloom. *Deep. Sea. Res.,* **40**, 459-477. [HPLC]

Mobley, C.D., 1994: Light and water; radiative transfer in natural waters. Academic Press, San Diego, USA

Morel, A., Prieur, L., 1977: Analysis of variations in ocean colour. *Limnol. Oceanogr.,* **22**, 709-722

Pingree, R.D. & Griffithis, K.D., 1978: Tidal fronts on the shelf seas around the British Isles. *J. Geophys. Res.,* **83**, 4615-4622.

Pinkerton M.H., & Aiken J., 1997: A moored databuoy for the calibration and validation of remote observations of ocean colour. PlyMBODy, a preliminary assessment. In RSS97 Observations and Interactions, 551-556. G. Griffiths & D. Pearson Eds. Remote Sensing Society 1997.

Prestidge, M.C. & Taylor, A.H., 1995: A modelling investigation of the distribution of stratification and phytoplankton abundance in the Irish Sea. *J. Plankton Res.,* **17**, 1397-1420.

Robins, D.B., Bale, A.J., Moore, G.F., Rees, N.W., Hooker, S.B., Gallienne, C.P., Westbrook, A.G., Maranon, E., Spooner, W.H. & Laney, S.R., 1996: AMT-1 Cruise Report and Preliminary Results. *NASA Tech. Memo. 104556, Vol. 35.* NASA Goddard Space Flight Center. 90pp.

Smith, R.C. & Baker, K.S., 1978: Optical classification natural waters. *Appl. Opt.,* **20**, 177-184.

Smith, R.C. & Baker, K.S., 1978: The bio-optical state of ocean waters and remote sensing. *Limnol. Oceanogr.,* **23**, 247-259.